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RESEARCH PAPER

Influence of climate and litter quality on litter decomposition and nutrient release in sub-tropical forest of Northeast India

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Abstract: Leaf litterfall, litter decomposition and nutrient return through litterfall of three dominant species, i.e. *Quercus serrata*, *Schima wallichi* and *Lithocarpus dealbata* were studied in different months throughout the year to assess the input and release of nutrient in the forest soil of a sub-tropical mixed oak forest of Manipur, northeastern India. Oaks in northeastern region of India are economically important species for the production of Tasar silk. The monthly litterfall ranged from 25.6 g·m^{-2} (July) to 198.0 g·m^{-2} (February) and annual litterfall was 1093.8g·m^{-2} in the forest site. At initial month (on November 3), the concentrations of N and C were the highest in *L. dealbata*, followed by *Q. serrata* and lowest in *S. wallichi*, whereas lignin and cellulose concentrations at initial month were the highest in *S. wallichi*, followed by *Q. serrata* and *L. dealbata. L. dealbata* (k =0.54) exhibited a high rate of litter decomposition, coinciding with high concentrations of N and C and low cellulose in the litter at initial month. However, low rate of litter decomposition in *S. wallichi* (k = 0.33) coincided with low value of N and C and highest value of lignin and cellulose at initial month. The remaining biomass in different months was positively correlated with the lignin, C, C/N ratio and cellulose, but it negatively correlated with nitrogen concentrations at initial month. The rate of litter decomposition was the highest in rainy summer months, owing to congenial environmental conditions and lowest rate of litter decomposition in cool and dry winter months.

Keywords: nutrient use efficiency; *Quercus serrata*; nitrogen; lignin and litter quality

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Introduction

Litter is composed of freshly fallen plant debris in the upper layer of undecomposed organic debris and had several vital functions in forest ecosystems. The release of nutrients from decomposing litter is an important internal pathway for nutrient flux in forested ecosystems. The decomposition rate of litter controls nutrient release in the soil. The balance between litter production and its decomposition also controls the size of the carbon reservoir within the soil (Kurz et al. 2000).

The decomposition of plant residues is influenced by the substrate quality, the physical and chemical environment factors and the decomposer organisms (Swift et al. 1979). Substrate quality indexes include nitrogen concentration, the ratio of carbon to nitrogen, lignin concentration and the ratio of lignin to nitrogen. Litter quality affects not only the rate of mass loss, but also the patterns and rates of nutrient mineralization and release (Santa Regina 2001). In India, oaks are found only in the Himalayan and northeastern region of India. Unlike the Himalayan oaks, which have a leathery texture leaves, Oaks in northeastern India are the host plant for tasar silk moth. Therefore, the conservation of different species of Quercus serrata and Lithocarpus dealbata is needed for the large scale production of silk. A number of studies have been carried out on litter dynamics and decomposition of litter in oak (Quercus serrata) forests around the world (Santa Regina et al. 1995; 1997) as well as the pattern of litterfall and nutrient return of the Himalayan oak (Pandey et al. 1981; Rawat et al. 1989). The nutrient use efficiency (NUE) and nutrient cycling of the tropical oak were studied by Vitousek (1982). Santa Regina (2001) also studied about the litterfall, decomposition and nutrient release in three semi arid forests of Spain. However limited information is available on the litterfall, decomposition and nitrogen release during litter decomposition in the oak forest from north-eastern India (Laishram et al. 1988; Arunachalam et al. 1998a). Therefore, the present work was undertaken to study (1) the litter production and leaf litter decomposition, (2) the effect of leaf litter quality on decomposition of leaf litter and (3) release of nitrogen, lignin and cellulose in

different months throughout the year in a subtropical mixed oak forest ecosystem at Langol Hills, Manipur, North-east India.

Materials and methods

Study site

The study site is situated in Langol Hills, at a distance of 7 km from Imphal City (N 24º44′–24º53′and E 93º53′–93º57′) at an altitude ranging from 780 m to 910 m above the mean sea level. The forest vegetation is dominated by *Quercus serrata*, *Schima wallichi* and *Lithocarpus dealbata*. The present forest falls under eastern Himalaya sub-tropical wet hill forests (8B/C1) classified by Champion and Seth (1968). The climate of the area is monsoonic with warm moist in summer and cool dry in winter. There are three distinct seasons consisting of summer (March–May), rainy season (June–October), and winter (November–February). The mean monthly maximum temperature ranges from 24.3ºC (January) to 32.7ºC (May) and mean monthly minimum temperature ranges from 3.2ºC (January) to 21.1ºC (July). Average annual rainfall of the area is 1140 mm and 68% to 70% of rainfall occurred during rainy season (Fig. 1). Soil is sandy loam with 31.6%–61.4% sand, 13.3%–14.8% clay and 22.7%–30.7% silt and pH ranges from 4.2 to 6.1 in the 0–10 cm soil layer. Forest floor is mull type and comprised of freshly fallen, partially decayed and decayed leaf litter type.

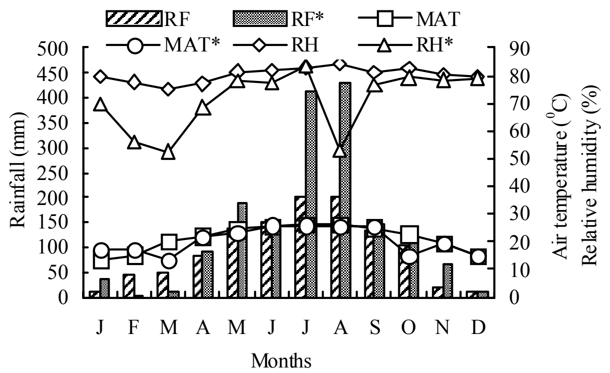

Fig. 1 Climatological data of study period (2002) and long-term climatological data (1993-2002)

RF, Rainfall; MAT, Mean air temperature; RH, Relative humidity (1993-2002). RF*, Rainfall; MAT*, Mean air temperature; RH*, Relative humidity (2002).

Litterfall

Ten trays of 50cm×50cm in size made of bamboo were randomly placed on the forest floor for the estimation of litterfall. Litter from each tray was collected on monthly intervals from January to December 2002. Litter from each tray was packed in separate polythene brought to the laboratory, sorted by species and litter type (i.e. leaves, branches and fruits and floral components) and oven-dried at 80ºC for a constant weight. The turnover rate (K) of litter was calculated according to Olson (1963).

$$K=A/(A+F) \tag{1}$$

where, A (g·cm^{-2}·a^{-1}) is the annual increment of litter (i.e., annual litterfall) and F (g·cm^{-2}·a^{-1}) is the mean monthly litter (annual average across months).

The nutrient use efficiency (NUE) was calculated as follows:

$$N_{ue}=\frac{M}{N} \tag{2}$$

where, N_{ue} is the nutrient use efficiency, M is the mass fall, and N is the nutrient in mass fall (Vitousek 1984; Lugo 1992).

Litter decomposition

For the estimation of litter decomposition rate, litterbag technique is used. Freshly fallen leaves of the three dominant species (*Q. serrata, S. wallichi* and *L. dealbata*) were collected from the field and then air-dried. The 10-g air-dried leaves of each of three species were placed in nylon litterbags of 10 cm×10 cm in size having a mesh size of 2 mm. The 45 litterbags of each species were placed on the forest floor in three different plots situated at the base, middle and top of the hill. Thereafter three litterbags from each plot for each species were collected at monthly intervals and brought to the laboratory. Then it was washed using tap water, followed by distilled water with gentle agitation on 1-mm mesh screen and dried at 80ºC in an oven to a constant weight. Rate of litter decomposition is determined from the mass loss of the litter in the litterbags in each month. The oven-dried litter mass was then ground into powder form for chemical analysis. Estimation of N was done using microkjeldahl's method (Bremner et al. 1982). Carbon content was calculated, following Mc Brayer and Cromack (1980), as 50% of ash-free dry weight. Lignin and cellulose were determined using Fibertec (Model No.1017 Hot extractor, Tecator). The decomposition constant (k) was calculated using the equation given by Olson (1963). Nutrient accumulation index (NAI) was calculated as follows:

$$N_{\mathrm{AI}}=\frac{W_{\mathrm{t}}\times X_{\mathrm{t}}}{W_{\mathrm{o}}\times X_{\mathrm{o}}} \quad \text{(Harmon et al. 1986)} \tag{3}$$

where, N_{AI} is the nutrient accumulation index, W_t (g) the dry weight at time t, X_t (μg·g^{-1}) the nutrient concentration at time t, W_{o} (g) the initial dry weight, and X_{o} (μg·g^{-1}) is the initial nutrient concentration. Multiple linear regression and 2 way ANOVA test were done using STATISTICA software.

Results

Litterfall

The monthly leaf litterfall ranged from 7.1 g•m^{-2} (July) to 122 g•m^{-2} (November) and the monthly total litterfall varied from

25.6 g•m^{-2} (July) to 198.0 g•m^{-2} (February), (Fig. 2). Maximum litterfall was contributed by Q. serrata with 31.9%, followed by S. wallichi (28.3%), L. dealbata (16.2%) and others (24.6%). The peak litterfall exhibited between November to March among the three species, having low value during July to October. The total annual litterfall amounted to 1093.8 g•m^{-2}•a^{-1}, out of which leaf litter of the three dominant species constituted for 67.2%, branch litter for 5.2% and fruit and floral parts for 2.9%. Litterfall refers to the total amount of litter collected from the forest and it constituted of leaf litterfall of all the species in the forest. The turnover rate of leaf litter varied from 0.921 to 0.923, respectively across the three species.

Nutrient use efficiency (NUE), N- return and nutrient accumulation index (NAI) through leaf litterfall

NUE of N for *Q. serrata, L. dealbata* and *S. wallichi* was 98.0, 70.4 and 113.9, respectively. N return was the highest for Q. serrata (30.0 kg•ha^{-1}•a^{-1}), followed by S. wallichi (25.1 kg•ha^{-1}•a^{-1}), and L. dealbata (21.9 kg•ha^{-1}•a^{-1}). The nutrient accumulation index (NAI) of N was 0.48 for *Q. serrata*, 0.30 for *S. wallichi*, and 0.14 for *L. dealbata*.

Initial chemical composition of litter

The leaf litter of S. wallichi exhibited the highest concentration of lignin (35.3%), followed by *Q. serrata* (24.0%) and *L. dealbata* (19.1%), whereas concentration of N was found to be the highest in *L. dealbata* (1.42%), followed by *Q. serrata* (1.02%) and *S. wallichi* (0.88%) at the initial month. The C/N ratio at the initial month was recorded to be 44.5, 50.6 and 58.6 in *L. dealbata, Q .serrata* and *S. wallichi*, respectively (Table 1). N concentration and C/N ratio at the beginning of the month were negatively correlated with percent weight loss per month while the concentrations of lignin, C and cellulose at the initial month were positively correlated with remaining biomass in all the three species. ANOVA of remaining biomass of the leaf litter of the three species in different months during the study period showed a significant difference (p<0.01).

Mass loss and release of nutrients during decomposition of litter

Maximum mass loss occurred in the leaf litter of *L. dealbata* (71%, at the end of one year), followed by *Q. serrata* (65.5%) and *S. wallichi* (53%). All the species exhibit a rapid mass loss during the rainy season and slow during winter season (Fig. 3a). The concentration of lignin increased slightly at the initial month in *S. wallichi, L. dealbata* and *Q. serrata* and thereafter it declined consistently in successive months (Fig. 3b). On termination of experiment after 12 months, the lignins of 58.6%, 79.0% and 74.3% at the initial month are decomposed in S. wallichi, L. dealbata and Q. serrata respectively.

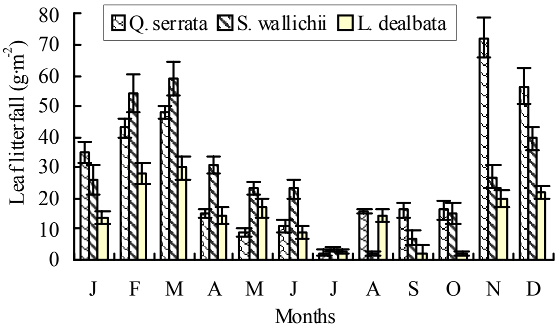

Fig. 2 Monthly leaf litterfall of the three dominant species (*L. dealbata, Q. serrata* and *S. wallichi*) throughout the year (Mean±S.E.).

The rate of lignin decomposition is more or less similar to that in *L. dealbata* and *Q. serrata*. Cellulose concentration decreased consistently in different months in all the species, leaving a small fraction at the end of experiment. The decrease was very fast in the initial months and more than 50% of cellulose is released within 4 months (Fig. 3c). The decay constants (k) were recorded to be 0.54, 0.46 and 0.33 for *L. dealbata, Q. serrata* and *S. wallichi*, respectively (Table 1).

Table 1. Percentages of C, N, lignin and cellulose and their ratios at the initial month for the three species (*S. wallichi*, *Q. serrata* and *L. dealbata*)

Species	C (%)	N (%)	Lignin (%)	Cellulose (%)	C/N ratios	Lignin/N	Annual decomposition constant (k)
Schima wallichi	51.48	0.878	35.3	21.4	58.63	40.21	0.328
Quercus serrata	51.62	1.02	24.0	16.0	50.61	23.53	0.462
Lithocarpus dealbata	63.27	1.42	19.1	14.3	44.56	13.45	0.539

N-release during leaf litter decomposition

During the initial month (December−January), there is a slow release of nitrogen in *Q. serrata* and *L. dealbata*. From January to May, N is immobilized and thereafter, N is released till December (Fig. 3d). However in *S. wallichi*, N is released from January to February and then immobilized from February to July. In the end of experiment, after 12 months, 36.9%, 49.8% and 52.1% of the original N are released in *S. wallichi, L. dealbata* and *Q. serrata* respectively. Analysis of variance (ANOVA) of nitrogen release of the three species throughout the study period indicated a significant difference at a level of P<0.01. The N-concentration in the remaining leaf litter as N function at the initial month is positively correlated with the remaining litter mass loss form *S. wallichi* (r^2=0.56), *L. dealbata* (r^2=0.74) and *Q. serrata* (r^2=0.75).

Relationship between mass loss and abiotic variables

The litter mass loss rate in three species was positively correlated for each species with all the tested abiotic variables, such as soil

moisture, soil temperature, rainfall, mean air temperature and relative humidity (Table 2). Among the abiotic variables, the rainfall was found to be the best predictor of litter mass loss, followed by soil temperature, mean air temperature and relative humidity. Soil moisture exhibited minimum variability in litter mass loss (Table 2).

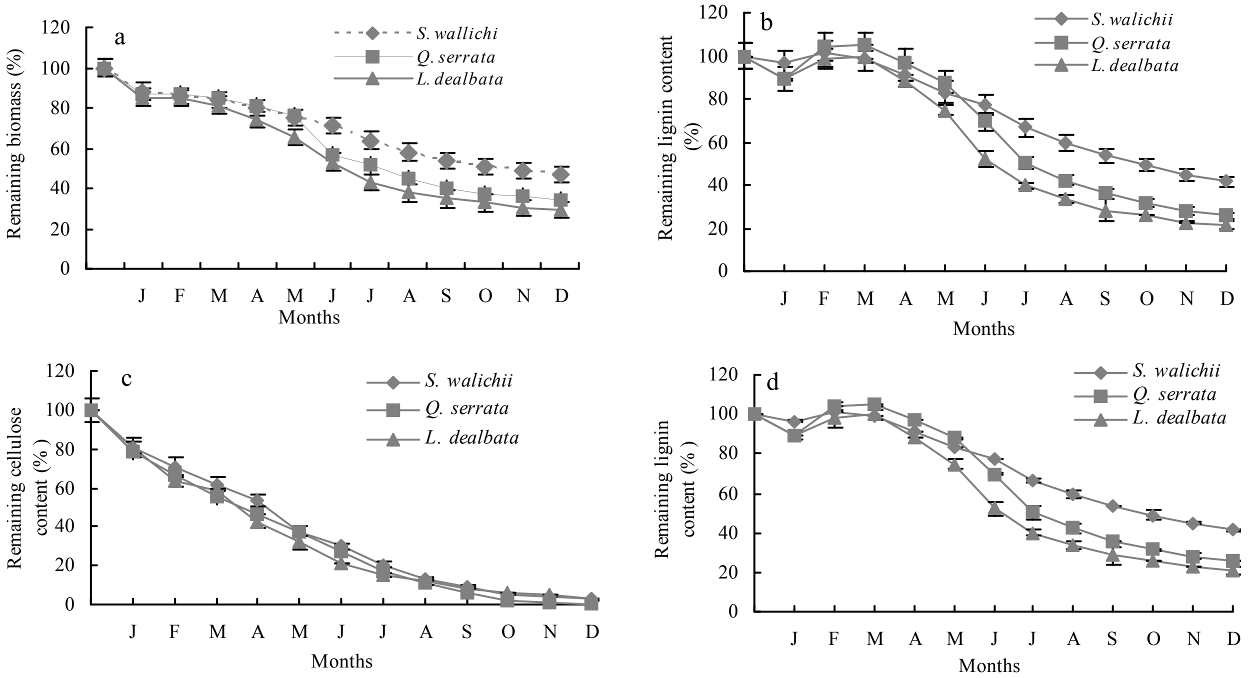

Fig. 3 Remaining biomass (a), lignin (b), cellulose (c) and nitrogen (d) content during decomposition of leaf litter of the three species (*L. dealbata*, *Q. serrata* and *S. wallichi*)

Table 2. Leaf litter decomposition rate (% wt. loss per month) as influenced by abiotic variables in *L. dealbata*, *Q. serrata* and *S. wallichi*

Name of species	N	Lignin	C	C/N	L/N	Cellulose
Quercus serrata	-0.57*	0.61*	0.96**	0.99**	0.73**	0.76**
Lithocarpus dealbata	-0.67*	0.65*	0.97**	0.99**	0.52*	0.87**
Schima wallichi	-0.94**	0.97**	0.96**	0.88**	0.99**	0.82**

Notes: ** $P<0.01$, * $P<0.05$.

Discussion

Pattern of litterfall

In the present study, maximum litterfall occurred during the winter season and minimum litterfall occurred during the rainy season, which may be due to the physiological response of the plants to the dry period. The litterfall pattern shows strong seasonality. According to results of Rapp (1984), the early senescence of plant organs, especially the leaf, is triggered by the dry period. Jenson (1974) declared that the occurrence of a dry period increases the fall of litter. Within the genetic views, the phenology of the senescence leaf depends on environmental factors, including humidity and temperature. Several researchers also declared that the largest amount of leaf litterfall was in the dry season (Sanchez et al. 1995; Singh et al. 1999; Santa Regina 2001). The monthly rainfall and litterfall have a significant inverse relationship (r = -0.69) in the present study, which is in conformity with the studies from Red Alder stand of Western Washington (Gessel et al. 1974); Terra firme forest of Central Amazonia (Franken et al. 1979); Alnus nepalensis stand of Eastern Himalaya (Sharma et al.1987) and Montane oak forest of Garhwal Himalaya (Pant et al. 1992).

The total annual litterfall is recorded to be 10.9 $t{\cdot}ha^{-1}{\cdot}a^{-1}$, which falls well within the reports from Bray et al. (1964) for equatorial forest (11 $t{\cdot}ha^{-1}{\cdot}a^{-1}$) and Jenson (1974) for tropical forest (5.5 to 15.3 $t{\cdot}ha^{-1}{\cdot}a^{-1}$). The present results of leaf litterfall (7.3 $t{\cdot}ha^{-1}{\cdot}a^{-1}$) falls well within the data for Oak forest of Garhwal Himalaya by Pant et al. (1992) (7.3 $t{\cdot}ha^{-1}{\cdot}a^{-1}$) and humid tropic woodland (6.22–7.83 $t{\cdot}ha^{-1}{\cdot}a^{-1}$) reported by Cooper (1982), (Table 3). The turnover rate of litter indicated that 92% of the forest floor is replaced each year, which is higher than the turnover rate of mixed oak conifer forests (54%–65%, Pandey et al. 1981) and

oak forest (64%–84%, Rawat et al. 1989) of Central Himalaya. The higher turnover rate in the present study may be due to a high temperature, rainfall pattern and lower elevation, favouring microbial activity and decomposition. Garkoti et al. (1995) stated a decline in turnover rate of litter with increase in elevation and decline in temperature.

N return through leaf litterfall and NUE and NAI

The N return through the leaf litterfall was recorded to be the highest for *Q. serrata* (30.4 $kg \cdot ha^{-1} \cdot a^{-1}$) and lowest for *L. dealbata* (21.0 kg $ha^{-1} \cdot a^{-1}$), even though the N concentration was the highest in *L. dealbata*, due to greater litter mass of *Q. serrata,* compared to the other species. The values of N return are close to the values reported by Garkoti et al (1995) from five tree species of Central Himalaya (4.20–26.78 $kg \cdot ha^{-1} \cdot a^{-1}$). Among the three species, *S. wallichi* exhibited the highest nutrient use efficiency (NUE), followed by *Q. serrata* and *L. dealbata* (Table 4). The NUE indicates that the present subtropical mixed oak forest is more efficient in N use than that of the Central Himalayan oak forest (Singh et al. 1992).

Table 3. Comparative data of total annual litterfall and leaf litterfall in different forest ecosystems of the world

Forest type	Litterfall per year ($t \cdot ha^{-1} \cdot a^{-1}$)	References
Equatorial forest	11	Bray and Gorham 1964
Tropical forest	5.5–15.3	Jenson 1974
Mixed oak Montane forest	9.3	Pant and Tiwari 1992
Central Himalayan high altitude forest	3.45–6.27	Garkoti and Singh 1995
Subtropical forest of Northeast India.	10.7-19.5	Arunachalam et al. 1998a
Mixed oak forest	10.9	Present study
Oak Conifer forest of Himalayan	4.12	Pandey and Singh 1981
Humid woodland	6.22	Cooper 1982
Mixed oak forest of Central Himalaya	3.75–5.90	Rawat and Singh 1989
Montane oak forest of Garhwal Himalaya	7.3	Pant and Tiwari 1992
Sub-tropical Mixed oak forest of North East India	7.35	Present study

The nutrient accumulation index of N (NAI) indicates that in all the three species, N is mineralized from the decaying leaf litter as NAI value of leaf litter is less than 1 in all the three species. According to the report of (Harmon et al. 1986), NAI value of 1 indicated that the decomposed matter contained the same mass of element when the litter was placed in litterbag. When NAI was less than 1, it indicated net mineralization of element from the decaying matter. When NAI was more than 1, NAI showed net accumulation of element by the decaying matter.

Table 4. Nitrogen return turnover rate (k) and NUE of N of leaf litter in the three species (*L. dealbata, Q. serrataus* and *S. wallichi*)

Species	N-return ($kg \cdot ha^{-1} \cdot a^{-1}$)	Turnover rate (k)	NUE of N
Quercus serrata	30.04	0.921	98.07
Lithocarpus dealbata	21.9	0.923	70.42
Schima wallichi	25.07	0.923	113.9

Effect of Initial litter quality on litter decomposition

L. dealbata exhibited the greatest weight loss (71.1%) at the end of a year, which may be due to high concentration of N and C and low concentration of lignin at th initial month in this species (Table 1). *S. wallichi* exhibited the lowest weight loss (53%) at the end of a year due to the low concentrations of C, N and high concentrations of lignin, which limits the growth of microorganisms. Albers et al. (2004) alleged that growth of microorganisms in litter decay is limited by nutrients Quideau et al. (2005) declared that leaf litter with significantly higher N content has a faster decay rate. Gillon et al. (1994) reported that mass loss and nutrient dynamics were related to contents of water soluble substances and C concentrations in the litter at the initial month. The rate of decomposition of lignin in leaf litter of *S. wallichi* is slower than that of *Q. serrata* and *L. dealbata*, which may be due to the differences in the properties of lignin and its concentration in the initial stage. Swift et al. (1979) and Hedges et al. (1979) stated that lignins from different sources often differ quite markedly in their properties. Lignin may slow decomposition because it interferes with the enzymatic degradation of cellulose and other carbohydrates, as well as proteins (Alexander 1977). Lignin concentration in the leaf litter of all three species showed an initial increase, followed by a decline, which may be due to the slow breakdown of lignin relative to other organic compounds. Similar patterns of lignin immobilization and release were reported by Maheswaran et al. (1987), Berg et al. (1991) and Musvoto et al. (2000) in leaf litter of different tree species. The species with high C/N ratios at initial month promoted faster decomposition of litter in the present study. This may be due to variations in decay rates of leaf litter from different species depending on litter quality and activity of decomposer organisms (Isaac et al. 2005). Laishram et al. (1988) and Taylor et al. (1989) alleged that litter with higher C/N ratio had a greater labile fraction and low mobility of nitrogen (O'Connell et al. 1996) and thus it decomposed more slowly than plant materials with low C/N ratios at initial months. The lignin, C, C/N ratio and cellulose concentration at the initial month are positively correlated with the remaining biomass in all the three species and negatively correlated with N (Table 5), which is in conformity with

the results (Mellilo et al. 1982; Laishram et al. 1988; Upadhyaya 1993; Arunachalam et al. 1998b; Musvoto et al. 2000). Thus lignin at the initial month is better predictor of remaining biomass than nitrogen at the initial month in the present study.

Table 5. Coefficient of correlations (r) values for remaining biomass (%) and leaf litter chemistry at the initial month in *L. dealbata, Q. serrata* and *S. walichi*

Name of species	RF	MAT	ST	RH	SM
Quercus serrata	0.85**	0.78**	0.83**	0.65*	0.53*
Lithocarpus dealbata	0.75**	0.82**	0.74**	0.64*	0.50*
Schima wallichi	0.93**	0.74**	0.85**	0.68*	0.55*

Notes: ** p<0.01, * p<0.05. RF is Rainfall; MAT is mean air temperature; ST is soil temperature; RH is relative humidity; SM is soil moisture.

The leaf litter of *S. wallichi* with the highest concentration of cellulose, decomposed slowly than that of *L. dealbata* with the lowest cellulose concentration, which may be due to difficulty of degradation of the cell wall by the microbes (Gallardo et al. 1993). Similar observation was reported by Guo et al. (2002).

Effect of abiotic factors on litter decomposition

The microbial biomass C, N and P also indicated to be highest during the rainy season and lowest during winter season in the study area (Devi et al. 2006), which may be the reason for the faster rates of decomposition during rainy months and slower rates of decomposition in cool and dry winter months. Similar seasonal patterns have also been reported by Okeke et al. (1992) and Misra et al. (1997). Shanks et al. (1961) stated that an increase in temperature of just a few degrees during the wet period may have significant effects on litter decomposition. In the present study, significant positive correlations were observed between rate of litter decomposition in all the three species and abiotic variables, including rainfall and air and soil temperature (Table 2). The annual decomposition constants (k) for different species i.e. *S. wallichi*, *Q. serrata* and *L. dealbata* in the present study varied from 0.33 to 0.54 (k), which of *L. dealbata* were more or less similar to the data for forests of Oregon (0.53) (Meentenmeyer 1979) and Semi arid forest of Spain (Santa Regina 2001).

Pattern of N release in leaf litter of the three species

In all the three species, i.e. *Q. serrata, L. dealbata* and *S. wallichi*, N is accumulated during the initial phase of decomposition and released in the latter phase, which may be due to incorporation of fungal and microbial protein. Several other studies have shown an immobilisation of nitrogen during the initial phase of decomposition (Bocock 1963; Vitousek et al. 1986; Singh et al. 1999). Nutrient immobilisation acts as nutrient conservation strategy for the plant, by storing the nutrient in an immobile form, which cannot be leached from the soil. Differences in nutrient release patterns are related to the different decomposer communities, which develop in litter of varying chemical composition. According to Jonsson et al. (2006), addition of leaf litters of different plant species leads to increase of different forms of N in the roots from mineralization and nitrification processes. Therefore, the addition of leaf litter of *Q. serrata, S. wallichi* and *L. dealbata* has increased the availability of N in the plants. The r2 value of the N concentration in the leaf litter as a function of the N to the remaining biomass of the leaf litter in the three species in the present forest falls within the range reported by Parton et al. (2007) in different ecosystems in which the r2 value ranged from 0.47 to 0.91 for N litter.

Conclusions

In the present study, the litterfall pattern shows seasonality. The cool and dry winter period induces high litter fall. Turnover rates of litter and NUE of N in the present mixed Oak forest are higher than those in the other Oak forests in India. Litter decomposition rates are higher during rainy months, perhaps because the warm, moist conditions promote the decomposition of litter. Substrate quality, especially C/N ratio, seems to be a major regulatory factor for the release of N during the decomposition of litter. N is immobilized during the initial months of decomposition, followed by continuous release, which lasts through the end of the one year experiment. Comparing with the other species in the present forest, more N is returned to the soil by the two species of oaks i.e. *Quercus serrata* and *Lithocarpus dealbata*. The decomposition rate of oaks is faster than that of Schima wallichi and nutrient use efficiency is also high in the oaks. Sikworm may be prefer to Oak as host for their high nutritional quality. Therefore, the leaf litters play an important role in returning the nutrients to soil through the process of litter decomposition.

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